National Aeronautics and Space Administration

NASA's Efforts to Commercialize Communications Services for Missions in Near-Earth Space

Greg Heckler (Presenter) - NASA
Philip Baldwin – NASA
Marie Piasecki – NASA
Erica Weir – Teltrium
Phoebe Wetherbee – Teltrium
Leland Toney - Teltrium

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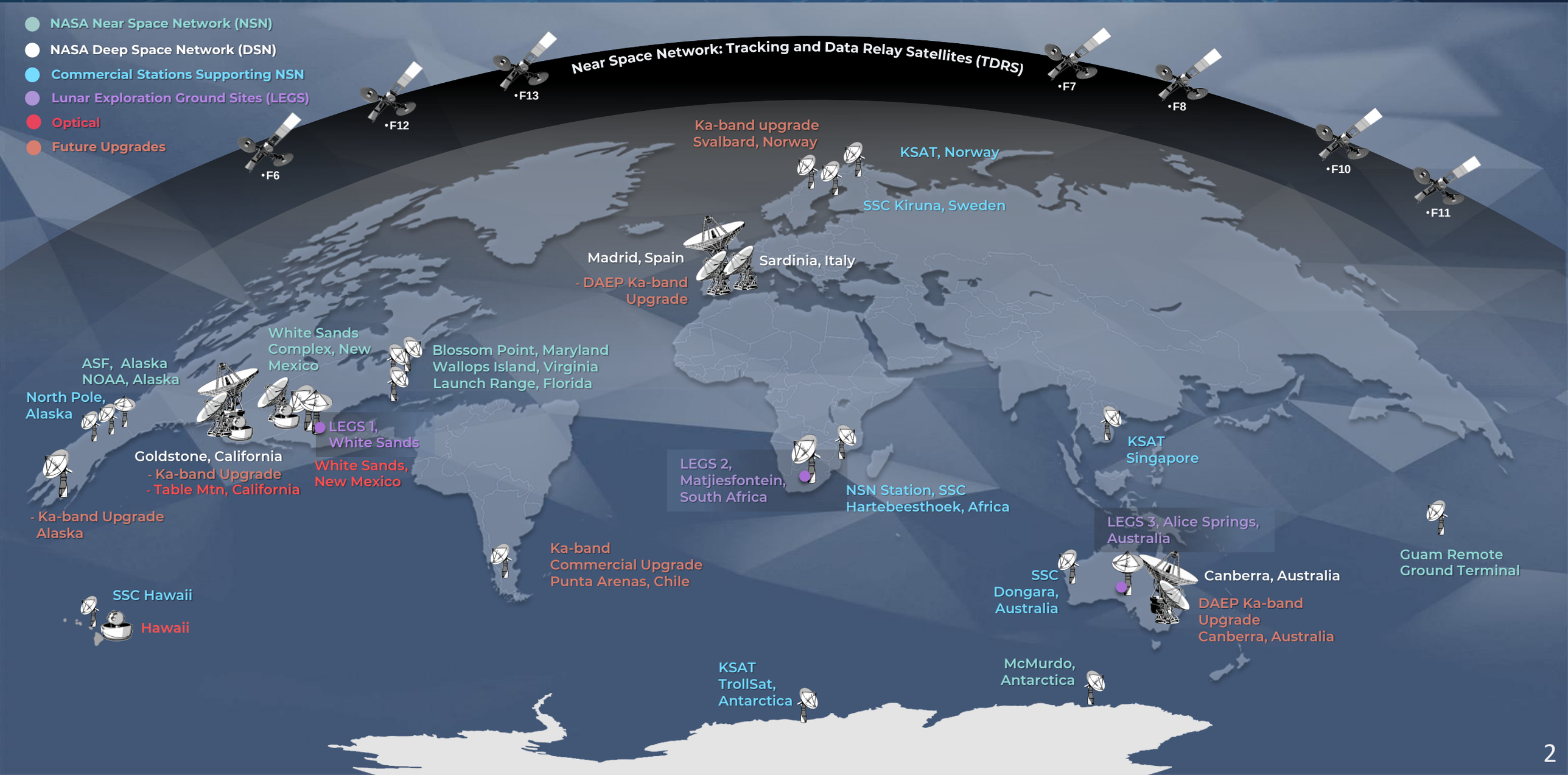
NASA's Communications Networks



Commercial Approach

"Divide and Conquer" approach is tailored to market capabilities and risks…

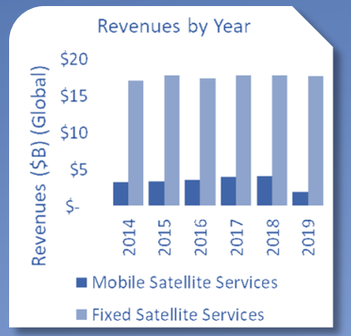
TDRS:
Commercialization Target

Measured Transition to Commercial SATCOM Services

2020 — 2030

- Time required to gradually transition
- Commercial SATCOM capability used for new missions; legacy missions fly out on current government capability

- NASA will no longer replenish Tracking and Data Relay Satellites (TDRS) fleet; current network can support users into the 2030s
- Significant U.S. commercial SATCOM infrastructure exists, however… industry capability tailored to non-space users
- Communications Services Project (CSP) to demonstrate the feasibility of commercial SATCOM
- Rolling wave approach of demonstrating new/expanded services over the 2020s



Ground Stations:
Commercialization Target

Rapid Commercialization of Direct-to-Earth (DTE) Services

2020 — 2030

- In 2021, 60% of mission passes were provided by commercial and university partners
- Near-term increase in services provisioned by current commercial & partner ground sites

- Transition to 100% commercial service; applies to existing and new missions
- Infuse new vendors drawing on vibrant and growing market
- Responsibility assigned to Near Space Network
- NSN project to integrate TDRS and commercial DTE services into a single user facing network

aws
KSAT KONGSBERG SATELLITE SERVICES
LEAFSPACE
SSC
RBC SIGNALS
Infostellar
ATLAS SPACE OPERATIONS

**Companies listed are illustrative of market activity, not indicative of NASA preference or commitments*

NASA-owned service capability Commercially-provided

SCaN Mission / User Technical Needs

Near-Earth Comm Assets

8 Tracking and Data Relay Satellites (with 14 associated ground terminals) targeted for low latency/constant **low earth orbit** missions

12 Government Direct-to-Earth antennas targeted for earth science **low earth, polar orbiting** missions

4 **NEW** government and commercial antennas

26 Certified commercial Direct-to-Earth antennas targeted for earth science **low earth, polar orbiting** missions

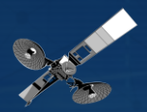
Frequencies

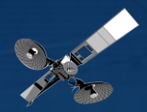

S-band


Ka-band


X-band


VHF


S-band


Ka-band


Ku-band

Orbits

- Launch/Ascent/Re-entry/Descent
- Sub-Orbital
- Low Earth Orbit (LEO)
- Medium Earth Orbit (MEO)
- Geosynchronous Earth Orbit (GEO)
- Highly Elliptical Orbit (HEO)/Molniya
- Lunar/Lagrange

Services

Data Transport / Data Rates [1]:

- Return Service: 10 bps – 600 Mbps
- Forward Service: 7.8 bps – 25 Mbps
- Multiple Spacecraft per Aperture (MSPA)
- Delay Tolerant Networking (DTN)
- Cloud Delivery

Science:

- Radio/ Radar Science services, Radio Astronomy/ Very Long Baseline Interferometry(VLBI)

Navigation and Radiometric:

- One-way Doppler
- Two-way Doppler
- Three-way Doppler
- Either PN-ranging or range tones
- Determination of orbital elements for mission platform navigation

[1] Data rates are dependent on modulation and data characteristics

NSN Service Acquisition

Key Activities:

- Returning missions are being targeted for transition in three tiers – to be largely complete FY24
- RFIs focused on commercial capabilities were released and evaluated in late 2020
- DTE Sources Sought (SS) released in Q4 FY21
- Soliciting for additional commercial service providers through RFP release in Q1 2023
- Contract awards are anticipated ~Q3 FY23

Category	Sub-Category	Sub-Category Name
1.0 (Direct-To-Earth)	1.1	Earth Proximity DTE
1.0 (Direct-To-Earth)	1.2	GEO to Cis-Lunar DTE
1.0 (Direct-To-Earth)	1.3	xCis-Lunar DTE
2.0 (Space Relay)	2.2	Cis-Lunar Relay

Communications Services Project Demonstrations

CSP Demo Objectives

- Validate commercial SATCOM capabilities through multiple end-to-end service demonstrations
- Provide recommendations on acquisition strategies and services that are viable for operations

In April, announced Funded Space Act Agreements for 6 demonstrations

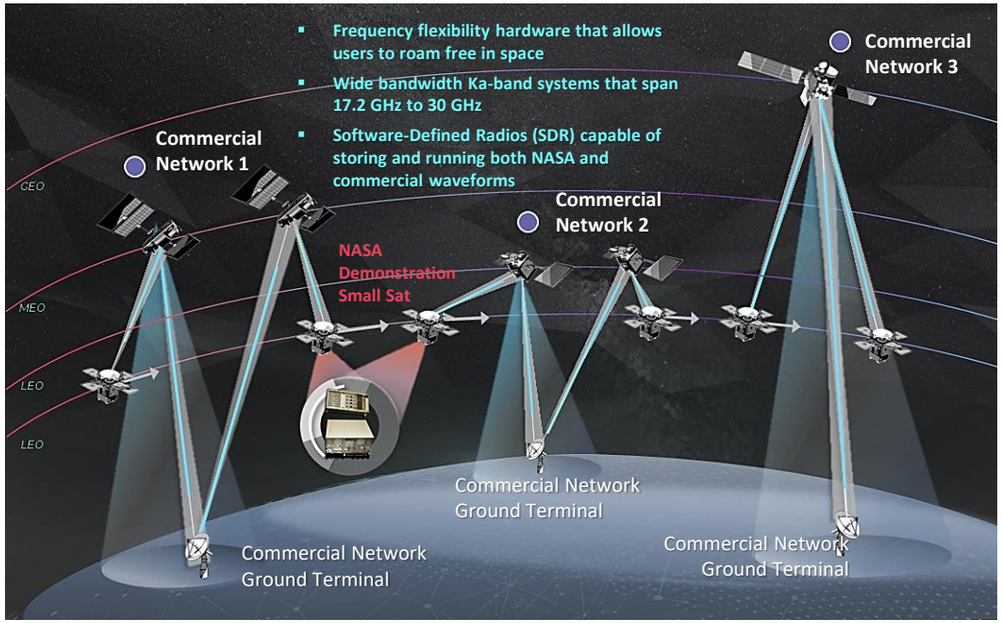
- Combined value of agreements is $278.5M
- Each company will match or exceed agency contributions – totaling more than $1.5B in cost-share investment

Planning for a second round of demonstrations beginning in ~2028

- New vendors and/or capability needs to be addressed

A seamless user transition will depend on resolution of spectrum, Interoperability and standards challenges

- satellite-to-satellite links are regulated both at the domestic (U.S. Table of Frequency Allocations) and international level (ITU Radio Regulations)



CSP SATCOM DEMONSTRATION AWARDEES

inmarsat

- Commercial GEO L-band relay network
- Low-rate SATCOM services
- Support to routine missions, contingency operations, launch, ascent, and early operations

amazon | project kuiper

- Optical LEO network
- High and low-rate services
- Supporting routine, contingency, and early operations

SES

- MEO and GEO networks with C-band and Ka-band
- High and low-rate services
- Supporting routine, contingency, launch and ascent, and early operations

SPACEX

- Optical LEO network
- High-rate services
- Routine, contingency, launch and ascent, and early operations support

TELESAT

- RF relay networks offering C- and Ka-band services for high and low-rate communications
- Support to routine missions

ViaSat

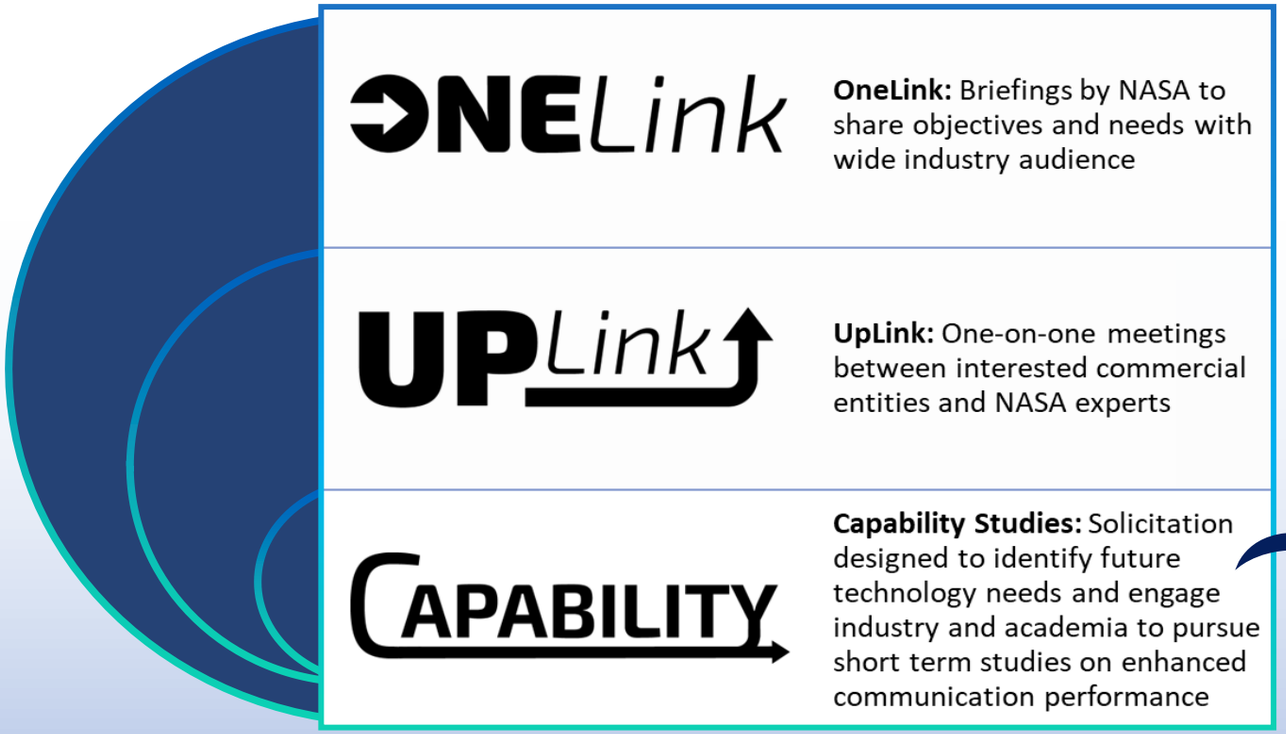
- GEO Ka-band relay network
- High- and low-rate communications services
- Routine launch and mission support

Commercialization, Innovation, and Synergies (CIS)

CIS identifies opportunities, nurtures diverse relationships, and implements collaborative solutions to enable or enhance needed capabilities and technologies in space communications.

Objectives:

- Proactively engage with the user community to better position SCaN in providing mission C&N solutions to meet the needs of each user
- Be a “go to” office for people seeking information on commercial and government space communications
- Provide an entry point for small businesses, academia, and entrepreneurs to provide niche services and capabilities to the space communications community



The CIS Capability Study NextSTEP-2 Omnibus BAA Appendix O will enable NASA to establish the standards, technology and mechanisms to make commercialization successful

In early October 2022, awards were made for the initial study areas:

- RF Compatibility Testing and Future Innovation
- Planning and Scheduling
- Integration of Optical Ground Terminal into Network Operations
- Digital Signal Processing in the Cloud (Software Defined Radios in Cloud)

The BAA provides a flexible platform and allow the future rounds of capability studies

TDRS and Mission Transition

The assessment of TDRS state of health is regularly updated

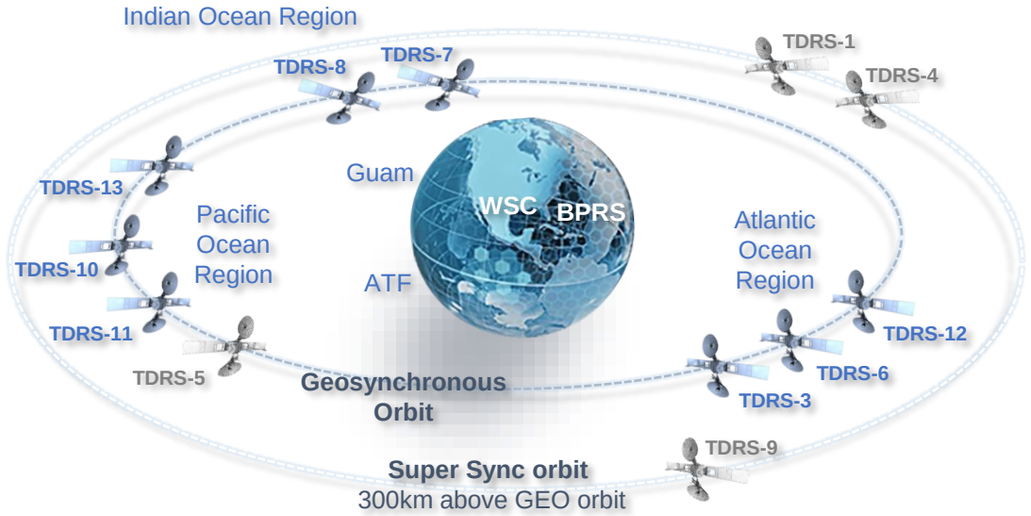
Constellation plan update

- Revisit constellation end-state scenarios/options based on F9 failure
- Repeat loading assessment and adjust options as applicable

Each mission to be engaged individually to socialize the flyout

- SCaN understanding of needs, assessment of impact and/or transition feasibility
- Dialogue and capture mission input for evaluation and planning
- Confidence in transition varies across the mission set based on user type

Challenge to resolve cost of future commercial services



National Science Foundation Antarctic Balloon Missions	Commercial LEO Destinations	Launch Vehicles	International Space Station (ISS)	Science Missions *Planning / Development- No TDRS commitment*	Science Missions *Development- committed to TDRS*	Science Missions *On Orbit*
Easily Modified mission comms • Relatively short duration • Payload interchange possible • Missions already evaluating commercial options	Mission can plan for commercial services	Ground based allowing for payload interchange or vendor selection utilizing an approved service	ISS flyout in 2030 constraints timeline Possible to install new comm equipment if needed	SCaN working with missions to socialize options • DTE • New relay offering coming online	Each mission must be addressed individually to identify • Impact to comm service • Other comm options such as ground solutions or new relay if possible	Each mission must be addressed individually to identify • Impact to comm service • Other comm options such as ground solutions or new relay if possible
Transition approach confidence:	Transition approach confidence:	Transition approach confidence:	Transition approach confidence:	Transition approach confidence:		
High	**High**	**High**	**Moderate**	**Moderate**	**No Transition**	**No Transition**

Wideband Multilingual Terminal – Demo to Ops

Interoperability is a challenge presented by commercial SATCOM systems

The wideband/multilingual user terminal can access both government and commercial capacity in Ka-band, from 17.7 – 31.0 GHz

Payload will be integrated into a York Space Systems S-Class bus

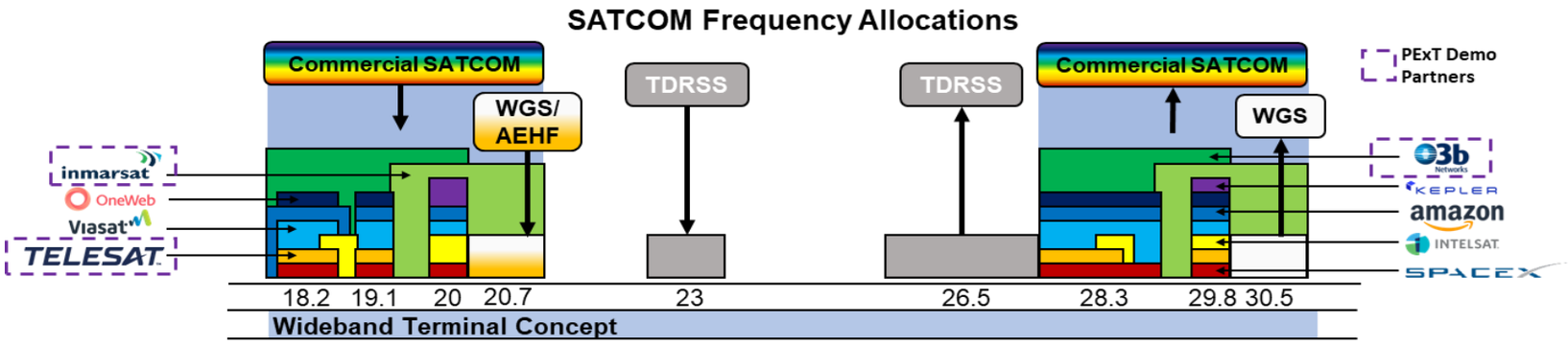
Preliminary Flight Terminal Layout

Key Milestones:

- APL was selected (end of FY21) to proceed to flight demonstration activity
- Planning for launch on Transporter-11
- Flight demo operations (~6 months) targeted to start February 2024

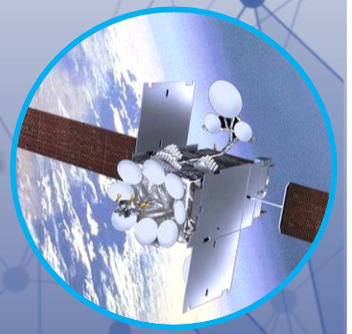
Post flight demo opportunity and actions

- Leverage existing partnerships to transfer wideband design / technology to industry
- Include resultant wideband terminal options in NSN services catalog



Inmarsat Global Xpress

- GEO Constellation
- 28 Steerable Antennas in orbit
- 7 new satellite Launching through 2025

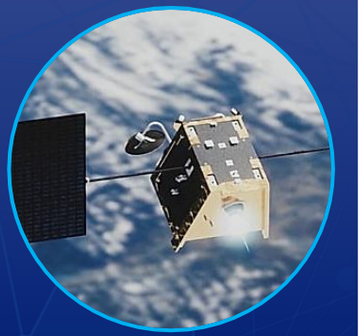


O3b mPOWER

- MEO Constellation
- Thousands of beams per satellite
- Launching late 2022
- 11 satellites launching through 2024

Telesat Blackjack

- LEO Constellation
- 2 steerable antennas per satellite
- 2 satellites in DARPA mission
- Launching 2022



Spectrum Regulatory Efforts

To augment existing space-Earth and inter-satellite frequency allocations available for space systems SCaN is pursuing regulatory recognition for the use of mobile satellite service (MSS) and fixed satellite service (FSS) systems for space-to-space use

- Coordinating at national and international levels to complete the studies and get regulatory approvals → World Radiocommunications Conferences (WRC)

WRC's are consensus-based, treaty level activities that occur every 3-4 years to agree upon modifications to the ITU Radio Regulation

WRC-23 will consider agenda item 1.17 to seek regulatory recognition for satellite-to-satellite operations in certain frequency bands allocated to the fixed-satellite service (Ku-band and Ka-band)

- WRC-23 will be held in the United Arab Emirates 20 Nov – 15 Dec 2023
- WRC-23 Final Acts will take effect ~ 1 Jan 2025

WRC-27 will tentatively consider agenda item 2.8* to seek regulatory recognition for satellite-to-satellite operations in certain frequency bands allocated to the mobile-satellite service (L-band and S-band)

- WRC-27 will be held near the end of 2027 with the Final Acts taking effect ~ 1 Jan 2029
- * WRC-27 agenda must still be developed at WRC-23 (no guarantees that such an MSS agenda item will adopted)

Standards and Interoperability

Historical interoperability limited to civil space organizations and associated standards bodies:

With shift to commercial services, standards solution should be developed with participation from commercial industry

Approach is to leverage the 3rd Generation Partnership Project*

- NASA joined as provisional (observer) participant in 2020, transitioned to official membership in 2021
- CIS is acting as the focal point for interaction with 3GPP

Focus of NASA SCaN 3GPP engagement efforts

- Understand scope off releases and implications for space users
- Make a case for inclusion of the space user as a unique use case for 5G
- Advocate for the evolution of 5G and NTN to support space use needs

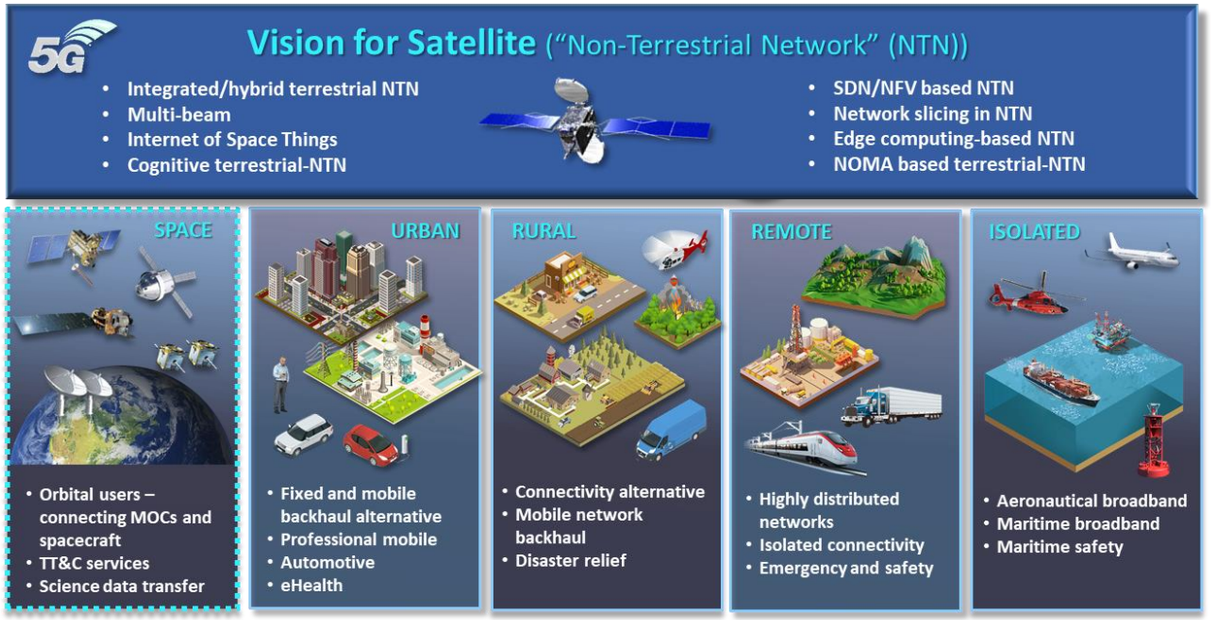
Inherent risk / challenge

- Outcome not completely within NASA control

Impact / result

- If standards fail to materialize and support interoperability objectives, functional interoperability is limited to user-side implementation → wideband multilingual terminal

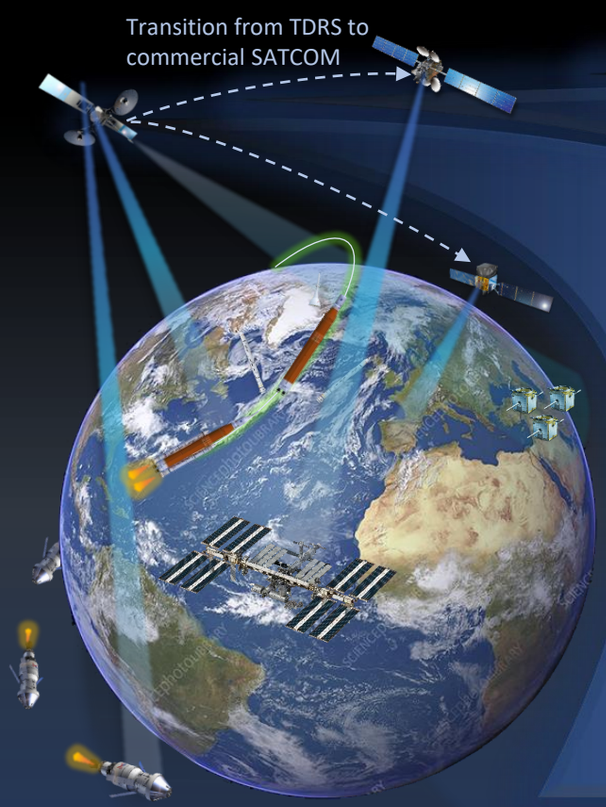
**Formed when cellular industry came together to define the 3rd, 4th, and now 5th generation standards that overcame limitations of previously fractionated market*



CSP team is exploring options and approaches for a Space Communications Consortium

- Modeled after similar industry groups such as the Seamless Air Alliance which was founded in 2018 to promote air passenger seamless access to the internet
- Foster broad industry engagement
- Leverage facilitation by a neutral party
- Foster working groups to help address NASA interests including interoperability, standards / specifications, and spectrum

Concluding Thoughts



Transition in Progress

Commercial shift underway with clear execution lanes established (DTE service shift, CSP and demos, wideband, spectrum regulatory)

Mitigations

Technical area of efforts underway to help mitigate uncertainty and reduce transition risk:

- Wideband multilingual terminal flight demonstration
- Working to define target architecture roles/responsibilities

Critical Timing

Several years needed to understand what commercial SATCOM can or can't do– CSP demos are providing this insight – and timing relative to TDRS flyout is critical

Applying Lessons

Intention to extend the lessons from near-Earth to the moon to provide proof of concept for the lunar market in the 2030s

SCaN

Space Communications and Navigation

National Aeronautics and Space Administration

Exploration, Enabled.

Greg Heckler – Division Manager, NASA SCaN Commercial Communications Services Division

Email: gregory.w.heckler@nasa.gov

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